

Claims:

1. An expendable container capable of measuring a residual quantity of stored expendable, the expendable container comprising:
 - an expendable tank configured to store the expendable and has a piezoelectric element attached thereto;
 - a detection signal generation circuit configured to charge and discharge the piezoelectric element, and generate a detection signal including cycle information, the cycle information representing a cycle of an output voltage wave of the piezoelectric element after the discharge; and
 - a control module configured to control the charge and the discharge of the piezoelectric element, wherein the cycle is available for determining whether the residual quantity of the expendable is greater than a preset level, and the control module is capable of vary a discharge characteristic of the piezoelectric element.
2. The expendable container in accordance with claim 1, wherein

wherein the control module is capable of varying a discharge time constant of the piezoelectric element.

3. The expendable container in accordance with either one of claims 1 and 2, wherein

wherein the control module is capable of varying a discharge time of the piezoelectric element.

4. The expendable container in accordance with any one of claims 1 to 3, wherein

the detection signal generation circuit comprises:

a voltage generation circuit configured to generate a predetermined potential difference between a first terminal with a higher potential and a second terminal with a lower potential;

the piezoelectric element having one end connected to the second terminal;

a charge control switch connected between the first terminal and the other end of the piezoelectric element, and configured to control on and off charging from the first terminal to the piezoelectric element according to a control output from the control module;

a discharge control switch connected between the other end of the piezoelectric element and the second terminal, and configured to control on and off discharging from the piezoelectric element to the second terminal according to the control output from the control module; and

a resistive circuit connected between the other end of the piezoelectric element and the second terminal, and having a variable resistance, wherein

the control module is configured to control the on-off of the charge control switch, the on-off of the discharge control switch, and the resistance of the resistive circuit.

5. A method of measuring a residual quantity of expendable stored in an expendable container, the method comprising the steps of:

- (a) providing an expendable tank configured to store the expendable and has a piezoelectric element attached thereto, and a circuit configured to charge and discharge the piezoelectric element;
- (b) setting a discharge characteristic of the piezoelectric element in a variable manner; and

(c) carrying out measurement,
the step (c) comprising:
(c-1) charging the piezoelectric element;
(c-2) discharging the piezoelectric element;
(c-3) generating a detection signal including information representing a cycle of remaining vibration of the piezoelectric element after the discharge; and
(c-4) determining whether the residual quantity of the expendable stored in the expendable tank is greater than a preset level, in response to the detection signal.

6. The method in accordance with claim 5, wherein
the step (c) further comprises the step of determining whether the stored residual quantity of the expendable is measurable in response to the detection signal, and returning a process to the step (b) in the case of determination of immeasurable; and
the step (b) comprises the step of setting a different value from a current setting on which the measurement is immeasurable to the discharge characteristic and proceeding the process to the step (c), in the case of determination of immeasurable.

7. The method in accordance with claim 6, the method further comprising the steps of:

(d) providing a non-volatile memory; and

(e) recording setting information representing a current setting of the discharge characteristic at a time of the measurement, into the non-volatile memory,

wherein the step (b) sets the discharge characteristic according to the setting information read from the non-volatile memory.

8. A computer program for causing a computer to control an expendable container capable of measuring a residual quantity of stored expendable, for setting a discharge characteristic of a piezoelectric element attached to the expendable container,

the expendable container comprising:

an expendable tank configured to store the expendable and has a piezoelectric element attached thereto;

a detection signal generation circuit configured to charge and discharge the piezoelectric element, and generate a detection signal

including information representing a cycle of remaining vibration of the piezoelectric element after the discharge;

a control module configured to control the charge and the discharge of the piezoelectric element, and vary a discharge characteristic of the piezoelectric element; and

a non-volatile memory configured to store setting information and residual quantity information, the setting information representing a current setting of the discharge characteristic, and residual quantity information, residual quantity information representing whether the residual quantity of the expendable is greater than a preset level,

the computer program causing the computer to carry out the functions of:

(a) reading out the setting information and the residual quantity information from the non-volatile memory;

(b) setting the discharge characteristic of the piezoelectric element, based on the setting information;

(c) confirming that the residual quantity of the expendable is greater than the preset level, based on the residual quantity information;

(d) generating the detection signal including the information representing the cycle of the remaining vibration of the piezoelectric element after the discharge, according to the confirmation;

(e) receiving the detection signal, and determining whether the residual quantity of the expendable is measurable, in response to the received detection signal;

(f) setting a different value from a current setting of the discharge characteristic on which the measurement is impossible to the discharge characteristic, and returning a process to the step (d) in the case of determination of immeasurable, in response to the determination of measurability; and

(g) recording the setting information representing the current setting of the discharge characteristic, into the non-volatile memory in the case of determination of measurable, in response to the determination of measurability.

9. A method of manufacturing an expendable container capable of measuring a residual quantity of stored expendable, the method comprising the steps of:

(a) measuring a characteristic of a piezoelectric element and

generating piezoelectric element characteristic information representing the characteristic of the piezoelectric element;

(b) providing an expendable tank configured to store the expendable;

(c) attaching the piezoelectric element, a non-volatile memory, and a detection signal generation circuit to the expendable tank, the detection signal generation circuit being configured to charge and discharge the piezoelectric element, and generates a detection signal including information representing a cycle of remaining vibration of the piezoelectric element after the discharge;

(c) setting discharge characteristic of the piezoelectric element according to the piezoelectric element characteristic information; and

(d) recording setting information representing the set discharge characteristic, into the non-volatile memory,

wherein the cycle is available to determine whether the residual quantity of the expendable stored in the expendable tank is greater than a preset level.

10. The manufacturing method in accordance with claim 9,

wherein

the step (a) comprises the step of measuring the characteristic of the piezoelectric element, and classifying a result of the measurement into one of multiple ranks, and

the step (c) comprises the step of setting the discharge characteristic of the piezoelectric element according to the classified rank.

11. A method of manufacturing an expendable container capable of measuring a residual quantity of stored expendable, the method comprising the steps of:

(a) providing an expendable tank configured to store the expendable;

(b) attaching a piezoelectric element, a non-volatile memory, and a circuit configured to charge and discharge the piezoelectric element, to the expendable tank;

(c) setting a discharge characteristic of the piezoelectric element in a variable manner;

(d) determining a capability of the measurement; and

(e) recording the setting of the discharge characteristic into

the non-volatile memory,

the step (d) comprising the steps of:

(d-1) charging the piezoelectric element;

(d-2) discharging the piezoelectric element;

(d-3) generating a detection signal including information representing a cycle of remaining vibration of the piezoelectric element after the discharge;

(d-4) determining whether the residual quantity of the expendable stored in the expendable tank is measurable, in response to the detection signal; and

(d-5) setting a different value from a current setting of the discharge characteristic on which the measurement is impossible, to the discharge characteristic, and returning to the step (d), in the case of determination of immeasurable,

wherein the cycle is available to determine whether the residual quantity of the expendable is greater than a preset level.

12. An expendable container capable of measuring a residual quantity of stored expendable, the expendable container comprising:
an expendable tank configured to store the expendable and

has a piezoelectric element attached thereto;

a detection signal generation circuit configured to charge and discharge the piezoelectric element, and generate a detection signal including cycle information, the cycle information representing a cycle of an output voltage wave of the piezoelectric element after the discharge; and

a non-volatile memory configured to store discharge characteristic setting information used to set a discharge characteristic of the piezoelectric element, according to piezoelectric element characteristic information representing a characteristic of the piezoelectric element; and

a control module configured to control the charge and the discharge of the piezoelectric element, wherein

the cycle is available to determine whether the residual quantity of the expendable stored in the expendable tank is greater than a preset level, and

the control module is capable of setting the discharge characteristic of the piezoelectric element according to the piezoelectric element characteristic information and the discharge characteristic setting information.

13. The expendable container in accordance with claim 12,
wherein

the piezoelectric element characteristic information
represents a rank selected among multiple ranks according to a
result of measurement of the characteristic of the piezoelectric
element, and

the control module sets the discharge characteristic of the
piezoelectric element according to the selected rank.